

## Tunable Antireflection Layers for Planar Bolometer Arrays

Ari-David Brown, David Chuss, Edward Wollack, James Chervenak, Ross Henry, and James Wray

It remains a challenge to obtain high-efficiency coupling of far-infrared through millimeter radiation to large-format detector arrays. The conventional approach of increasing detector coupling is to use reflective backshorts. However, this approach often results in excessive systematic errors resulting from reflections off the backshort edge. An alternate approach to both increasing quantum efficiency and reducing systematics associated with stray light is to place an antireflective coating near the front surface of the array. When incorporated with a resistive layer and placed behind the detector focal plane, the AR coating can serve to prevent optical ghosting by capturing radiation transmitted through the detector. By etching a hexagonal pattern in silicon, in which the sizes of the hexes are smaller than the wavelength of incident radiation, it is possible to fabricate a material that has a controllable dielectric constant, thereby allowing for simple tunable optical device fabrication. To this end, we have fabricated and tested tunable silicon "honeycomb" AR layers and AR/resistive layer devices. These devices were fabricated entirely out of silicon in order to eliminate problems associated with differential contraction upon detector cooling.



# Tunable Antireflection Layers for Planar Bolometer Arrays

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## Introduction:

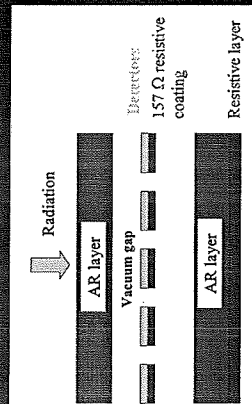
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## Envisioned Absorber/AR Coating Strategy:



A vacuum gap is added between the detectors and AR coating so as to preserve the thermal properties of the detectors.

The backside absorber, consisting of AR and resistive layers, is used instead of a backshort, which requires precise positioning.

## Si Dielectric Honeycombs as AR Coatings:

Antireflection conditions:

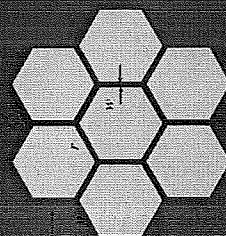
1.  $t = (\lambda_0/4) \epsilon_{AR}^{0.5}$
2.  $\epsilon_{AR} = \epsilon_{Si}^{0.5}$

Effective medium theory ( $r \ll \lambda_0$ ):

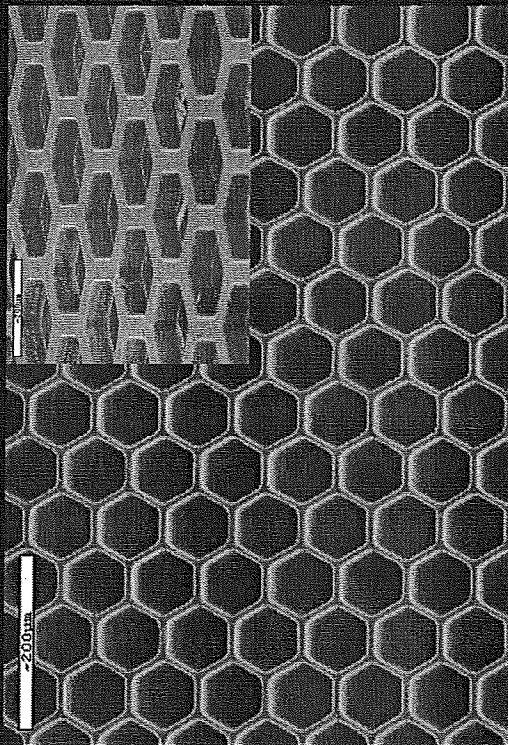
$$\epsilon_{eff} = ((\epsilon_r, 0, 0), (0, \epsilon_p, 0), (0, 0, \epsilon_z));$$

$$\epsilon_r = 1 + (\omega/\omega_p)(0.7375\epsilon_{Si} - 0.521)$$

$$\epsilon_p = 1 + (\omega/\omega_p)(0.6715\epsilon_{Si} - 0.4615)$$

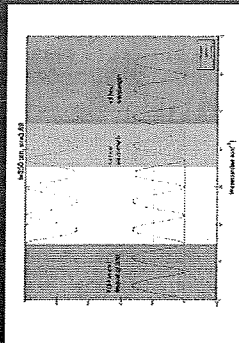


$\lambda_0$  is the wavelength of incident radiation;  $r$  is the AR coating thickness in  $\lambda_0$  dielectric constant.



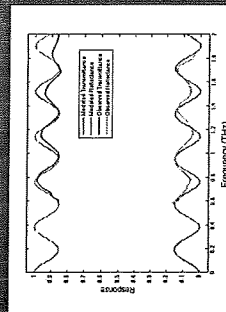
Plan view SEM micrograph of silicon dielectric honeycombs,  $r = 13$  microns,  $t = 40$  microns, and  $l = 300$  microns. INSET:  $r = 40$  microns,  $t = 121$  microns, and  $l = 40$  microns. In both cases, the honeycomb array extended over a  $1\text{ cm} \times 1\text{ cm}$  area.

## Expected AR Coating Performance:



We designed devices that were expected to have several transmittance and reflectance fringes within the narrow FTS measurement band — depicted in white — in wavenumber space.

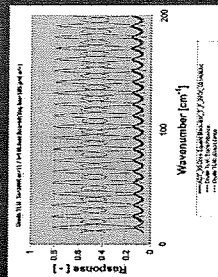
## Observed AR Coating Performance:



Best-fit model:  
 $r = 270$  microns  
 $\epsilon = 2.3$   
 Anticipated  
 $r = 300$  microns,  
 $\epsilon = 2.5$

Sideval profile might be tapered, and, consequently, new model needs to be constructed.

## Optical Measurement of Implanted Silicon Resistance:



Target sheet resistance:  
 $30 \Omega/\text{sq}$  ( $T = 0.4 \text{ K}$ )

Measured sheet resistance:  
 $60 \Omega/\text{sq}$  ( $T = 295 \text{ K}$ )  
 $\sim 30 \Omega/\text{sq}$  (cold)

Implant recipe works.

## Future Work:

\*Implement measured and theoretical sheet resistance in modeling. Get sheet resistance to match theoretical value.

## Acknowledgments:

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